

ABSTRACT

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Guideline Requirements for Serviceable Spacecraft Grasping/Berthing/Docking Interfaces Based on Simulations and Flight Experience (Survey Paper)

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As space vehicles and structures become larger and more complex, the development of systems to assist humans in assembling, operating, maintaining, and performing space rescue or retrieval of these vehicles and structures becomes increasingly important. With the diversity of international spacecraft, both manned and unmanned, planned to be in orbit in the not too distant future, a set of guidelines for berthing and docking subsystems is mandatory if servicing, resupply and retrieval is to become practical on an international level. Successful interaction between these space systems, and with ground and/or space-based humans, requires standardized and effective operational interface designs, particularly with respect to space grasping/berthing/docking interface mechanisms. This paper defines the spacecraft mechanical interfaces necessary to create a standard dynamic envelope for joining two free-flying spacecraft in a 'hard' berth or dock with each other in space.

A review was made of past space flights and dynamic simulations dating back to 1962 to obtain necessary parameters and their values for successful manually controlled and autonomous spacecraft docking/berthing. The various spacecraft docking/berthing mechanisms and concepts are illustrated along with their dynamic capture and impact tolerances including maximum contact velocity along the approach axis and in the y-z plane; capture linear misalignment tolerances; and maximum capture roll, pitch, and yaw angles. From this data sets of recommended guideline parameters were developed for autonomous and manual impact docking tolerances, non-impact grasping/berthing tolerances (end effectors), berthing contact conditions, and alignment tolerances after rigidizing. Also, detailed requirements were developed for mechanical design interface features, as well as latching, unlatching, and separation tolerances. This data was drafted in the form of a proposed ANSI Standard guideline, reviewed and added to by members of the committee representing several spacecraft manufacturers, NASA, and the USAF, and a consensus was reached.

By defining the active parameters and basic groundrules which all spacecraft designed for docking or berthing should meet, a high level of cross program interoperability and interchangeability will result and lead to the development of standardized and effective operational designs.

¹ Chairman of the Mechanical Interfaces Committee of the NASA-JSC Space Assembly and Servicing Working Group Interface Standards Committee (SASWG-ISC) under the direction of James S. Moore and Charles T. Woolley of the NASA-JSC New Initiatives Office.